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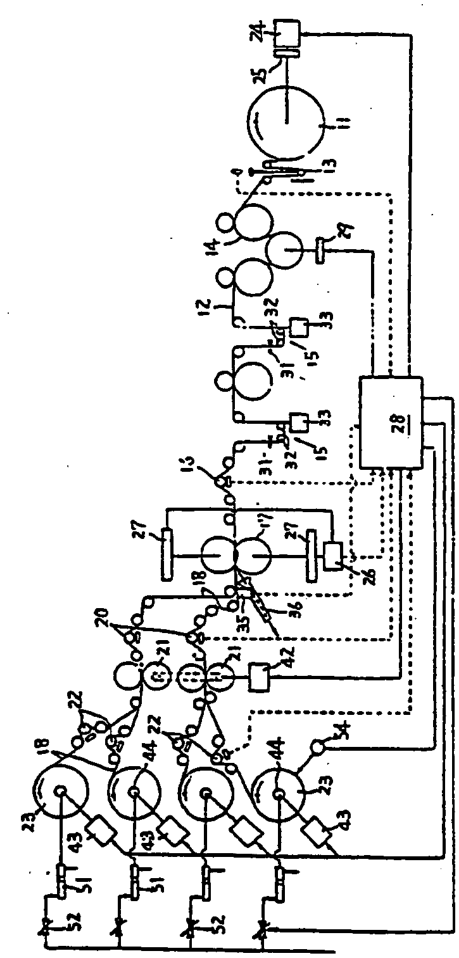
(54) Method and apparatus for splitting amorphous metal foil.

(57) This invention relates to a highly reliable technique of splitting a broad roll of amorphous metal foil (herein-after referred to as original roll) fed from foil feeder reel into narrow ribbon tapes and taking up them on a plurality of take-up reels that effectively eliminates any meandering motion of the roll, controls the drive motors and collects trashy ribbon tapes.

FIG.1



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METHOD AND APPARATUS FOR SPLITTING AMORPHOUS METAL FOIL

This invention relates to a method and an apparatus for splitting a broad roll of amorphous metal foil (hereinafter referred to as original roll) fed from a reel into a plurality of narrow ribbon tapes and taking them up on so many different reels.

Amorphous alloy foil is normally produced in the form of a broad roll, which is then split into a number of narrow ribbon tapes before they are used for preparing, for instance, cores of choke coils and other applications.

An original roll is normally cut into narrow tapes by using rotary cutters made of hard metal or high speed steel, following a process as described below.

Firstly, a reel that carries an original roll (hereinafter referred to original roll reel) is set in position so that the roll of foil is unwound and fed as the original roll reel is driven to rotate. Then, the original roll is split into a number of narrow ribbons, which are taken up on take-up reels arranged in parallel on a common rotary shaft except for those made form marginal areas of the original roll. The ribbon tapes made from marginal portions of the original roll are randomly taken up on a paper cylinder and thrown away as trash.

The process as described above, although currently popularly used, involves a number of problems to be resolved. One of the problems is related to the step of splitting an original roll by rotary cutters, while another is related to disposal of trash ribbon tapes. There is still another problem that arises when ribbon tapes are taken up.

Now, these problems will be discussed in greater detail.

What is particular with a roll of amorphous metal foil is that it does not evenly proceed and can meander as it is fed from a reel. Unlike aluminum foil, polyethylene film or paper, an original roll of amorphous metal foil, if cut, often shows an uneven cross section which is thick at the middle and loses its thickness as it reaches the lateral edges. A roll of amorphous metal foil having such a cross section can easily take a winding course when it is fed from a reel so that it can be cut slantly or zigzag and sometimes it may not be cut at all when its course is moved away from the cutters. The table below shows for comparison the irregularities of thickness of an amorphous metal foil, a copper foil and a plastic film.

Another problem particular with an original roll of amorphous metal foil is that it has to be always appropriately tensioned when it is fed to cutters.

A slackened original roll can be easily undulated and

Table

	thickness (μm)	irregularity of thickness (%)	ductility
amorphous metal foil	25	±10-15	low (brittle)
copper foil	35	±5 or less	medium
plastic foil	25	±1 or less	high

meander so that it is subjected to the above described problems, whereas a too tightly tensioned original roll can slip on the cutters leaving the cutters idly running under it.

In order to give an original roll a correct tension and avoid any over- and under-tension, the operation of splitting the original roll of amorphous metal foil with cutters should be synchronized with the operation of feeding it to the cutters. This by turn requires synchronized operation of the drive motors of the cutters and the original roll or those of the cutters and th pinch rolls for pulling th amorphous metal f il from the original roll. Particularly, during the rise time required for the original roll to reach a constant rate of rotation from the start of motion, fine control of the two motors is needed in order to secure their synchronized operation. Such synchronization is very difficult when the motors are manually operated.

Besides, the rate at which the amorphous metal foil is fed from the riginal roll decreases as the volume of the original roll is reduced in the course f cutting operation to increase the tension applied to the amorphous metal foil. Therefore, it is desirable that the drive motor of the original roll reel is controlled as a function of the volume of th original roll left n the original roll reel.

Moreover, there arises a problem at the time of taking up the split ribb n tap s of am rphous metal foil on take-up reels, where the volume of ribbon tape on a take-up reel at the middle is greater than those of ribbon tapes on reels near and at the lateral edges because of the difference of thickness of amorphous metal foil which is greater at the middle than at the lateral edges of the original roll as described above. Consequently, ribbon tapes having a smaller thickness can show a loose relationship with the respective rotary cutters and are loosely taken up by the respective take-up reels. Thus, the force applied to the take-up reels arrang d on a common rotary shaft is varied depending on the location of the reels, leading to imbalance of the force applied to the reels that can results in unintentionally broken ribbon tapes. Such trouble of broken ribbon tapes can occur particularly when the amorphous metal foil is fed and split at a high rate of more than 50 m/min.

A ribbon tape of amorphous metal foil that has been loosely taken up by a take-up reel can be tightened on the reel when it is pulled by external force. Therefore, when such a loosely wound ribbon tape is taken out from the reel for manufacturing choke coil cores, it would not come out from the reel at a constant rate so that the operation of manufacturing choke coil cores can be obstructed and defective products can appear at a relatively high rate.

Finally, disposal of ribbon tapes obtained from marginal portions of an original roll is accompanied by the following problem.

If the tapes are taken up randomly on a paper cylinder in a conventional manner, the rate of splitting an original roll cannot be made greater than 100 to 200 m/min because a rate beyond that can result in unintentionally broken tapes and inevitably interrupted operation to reduce the efficiency of the overall operation. Besides, the randomly taken up ribbon takes are simply thrown away as trash to further reduce the efficiency of the operation.

In view of the above described problems, it is therefore an object of the present invention to provide a method for preventing any meandering motion of an original roll and feeding it to rotary cutters under appropriate tension without requiring any adjustment of rate of rotation of related drive motors for synchronized operation.

A second object of the invention is to provide a method for controlling the rate of rotation of the drive motor for feeding the original roll as a function of the volume of the original roll left on the original roll reel.

A third object of the invention is to provide a method for efficiently splitting an original roll without requiring any particular operation for handling defective ribbon tapes as well as an apparatus for carrying out the method.

A fourth object of the invention is to provide a method for ensuring an equal level of tension to be applied to the take-up reels of produced ribbon tapes as well as an apparatus for carrying out the method.

According to the invention, the first object of the invention is achieved by providing a method of preventing meandering motion of an original roll by means of a specifically designed apparatus and of operating the cutter drive motor and the original roll feeding drive motor with a constant ratio of rotation.

More specifically, there is provided a method of splitting a broad roll of amorphous metal foil fed from a foil feeder reel into a plurality of ribbon tapes by rotary cutters using a sensor for detecting the lateral edges of the roll and a pair of rollers, wherein a meander-preventive device is provided for preventing meandering motion of the amorphous metal foil by modifying the angle formed by the rollers according to the output signal from the sensor and the drive motor for driving the rotary cutters and the drive motor for feeding amorphous metal foil are operated with a constant ratio of rotation.

With a method according to the invention as described above, any meandering motion of a roll of amorphous metal foil fed from a foil feeder reel due to an irregular thickness and irregular lateral edges of the foil can be corrected so that the foil is always rectangularly applied to the cutters at a predetermined position. Moreover, since the rate of rotation of the drive motor for feeding amorphous metal foil is automatically adjusted to maintain a given ratio of rotation relative to the rate of rotation of the drive motor for driving the rotary cutters, the foil does not show any lack of tension or any excessive tension even during the rise time required for the foil feeder reel to reach a constant rate of rotation from the start of motion.

The second object of the invention is achieved by providing a method of controlling the drive motor for feeding amorphous metal foil by detecting the displacement of a dancer roll arranged between the foil feeder reel and the rotary cutters in such a manner that it is firmly kept in contact with the amorphous metal foil and moves back and forth as a function of the tension of the amorphous metal foil.

With a method as described above, the dancer roll comes forward (downward in Fig. 1) when the amorphous metal foil becomes loos between the foil feeder reel and the rotary cutters and the displacement of the dancer roll causes to reduce the rate of rotation of the drive motor for feeding amorphous m tal foil and hence the rate of feeding th foil. To the contrary, the dancer roll moves backward (upward in Fig. 1) when th amorphous metal foil becomes too tight between the foil feeder reel and the rotary cutters and the displacement of th dancer roll causes to increase the rate of rotation of the dancer roll f r feeding amorphous metal foil and hence the rate of feeding the foil. Thus, the rate of rotation of the drive motor for feeding amorphous metal foil is modified as a function of the volume of amorphous metal foil on the foil fe d r reel and hence the amorphous metal

foil is fed to the rotary cutters with a same level of tension without becoming too loose or too tight.

In order to control the drive motor for feeding amorphous metal foil as a function of displacement of the dancer roll, the displacement may be converted into an electric signal that alters the voltage applied to or the resistance connected to the drive motor to increase or decrease the rate of rotation of the motor appropriately whenever the dancer roll is displaced from its normal position.

An alternative method for achieving the second object of the invention consists in detecting the volume of amorphous metal foil remaining on the foil feeder reel by means of a sensor for detecting the volume and controlling the drive motor for feeding amorphous metal foil as a function of the detected volume.

The sensor for detecting the volume of amorphous metal foil remained on the foil feeder reel may comprise, for instance, a spindle which is kept in contact with the outer surface of the amorphous metal foil on the foil feeder reel and radially moves back and forth depending on the volume of amorphous metal foil remaining on the foil feeder reel so that the displacement of the spindle is converted into an electric signal that alters the voltage applied to or the resistance connected to the drive motor to increase or decrease the rate of rotation of the motor appropriately. However, it may be replaced by any known mechanical, electric, optical and/or ultrasonic sensing means.

With a method as described above, the rate of rotation of the drive motor for feeding amorphous metal foil is low when a large volume of amorphous metal foil is left on the foil feeder reel and increases as the volume of amorphous metal foil decreases on the foil feeder reel.

The third object of the invention is achieved by providing a method of introducing trashy ribbon tapes produced by marginal portions of a roll of amorphous metal foil into a hard blasting pipe and blasting them by compressed air. More specifically, there is provided a method of collecting and removing trashy ribbon tapes produced by marginal portions of a roll of amorphous metal foil when the amorphous metal foil is split into ribbon tapes by means of rotary cutters, wherein said trashy ribbon tapes are introducing into a hard blasting pipe and blasted by compressed air.

When ribbon tapes of amorphous metal foil is introduced into a blasting pipe and blasted by compressed air, the brittle amorphous metal foil collide against the pipe wall and are broken to pieces as they move very fast in the pipe. The small pieces of amorphous metal foil are finally ejected from the pipe.

The inventor of the present invention has discovered that ribbon tapes of amorphous metal foil are twisted and damaged if they are mixed with compressed air in a large mixer before they are introduced into a blasting pipe so that they may become even more brittle and easily broken to pieces as they pass through the blasting pipe.

Therefore, the above described method is characterized by that trashy ribbon tapes of amorphous metal foil are mixed with compressed air and then introduced into a hard blasting pipe. An apparatus for carrying out the method comprises an ejector for collecting trashy ribbon tapes produced during the operation of splitting a roll of amorphous metal foil by way of a collector pipe, a mixer for mixing the trashy ribbon tapes collected by the ejector with compressed air and a hard blasting pipe connected to the mixer.

While there may be provided a pair of apparatuses as described above for carrying out the method, each for trashy ribbon tapes produced from a lateral marginal portion of a roll of amorphous metal foil, trashy ribbon tapes from two lateral marginal portions of a roll are preferably collected and introduced into a single mixer and blasted in a blasting pipe. When trashy ribbon tapes form two lateral marginal portions of a roll are collected together, they will collide against one another and be damaged even more fiercely so that the operation of blasting the tapes may be carried out more efficiently and effectively while a single mixer and a single blasting pipe can be commonly used for trashy ribbon tapes from two lateral marginal portions to simplify the overall configuration of the system of blasting tapes. According to an experiment conducted by the inventor of the invention, the maximum rate of operation of splitting a roll of amorphous metal foil was 80 m/min, whereas the rate was raised to 200 m/min by installing a mixer for collecting ribbon tapes from the two lateral marginal portions of the roll.

A blasting pipe, an ejector and a mixer to be used for the purpose of a method and an apparatus according to the present invention may be made of any hard and strong material. Feasible candidates for these components include metal pipes such as iron pipes, stainless steel pipes, aluminum pipes or steel pipes, plastic pipes such as FRP pipes and tempered glass pipes. A blasting pipe should be longer than 5 cm and have an inner diameter betwe n 5 and 50 mm. Preferably, it has an inner diameter between 10 and 30 mm and is as long as somewhere between 30 and 200 cm.

Although the ejector may be arranged downstream relative to the blasting pipe, it is preferably arranged upstream relative to the pipe and the mixer, if the latter is installed, and within a guide pipe having an inlet port open for the lateral marginal portions of the roll of amorphous metal foil. The ejector is provided with a neck portion having a reduced diameter. While the inner diameter of the neck portion should be larger than the width of a ribbon tape, an excessively large diameter can reduce the force of suctioning ribbon tapes. The inner diame-

ter of the neck portion is between 3 and 30 mm and preferably between 5 and 20 mm.

Whil the pressure of compressed air introduced into the ejector is related to the rate of ribbon tapes passing through the ejector, the width of ribbon tapes, the inner diameter of th neck portion of the ejector and the inner diamet r and the length of the blasting pipe, it is should be greater than 3 kg/cm^2 and preferably it is between 5 and 10 kg/cm^2.

The velocity and the rate of compressed air passing through the blasting pipe are respectively between 20 and 40 m/sec and between 200 and 600 kl/min.

If two guide pipes are installed for collecting trashy ribbon tapes from the two lateral marginal portions of a roll of amorphous metal foil and a mixer is provided for mixing the tapes, the angle formed by the two guide pipes (incident angle) may be between 5 and 120°, although long guide pipes are required if the angle is too small and a too large angle results in collision of two gas flows coming from the two guide pipes to reduce the force to send ribbon tapes into the blasting pipe. Therefore, the incident angle is preferably between 30 and 90°.

A method and an apparatus for achieving the fourth object of the invention is intended to rotatably arrange a plurality of take-up reels on common rotary shafts and loosely hold them by holding means so that the take-up reels on any of the common rotary shafts become idle on it whenever the tension applied to ribbon tapes on them exceeds a threshold value.

More specifically, a method and an apparatus for separately taking up individual ribbon tapes produced by splitting a broad roll of amorphous metal foil by take-up reels arranged zigzag and driven by respective motors are characterized by that the take-up reels are rotatably arranged on common shafts and held by holding means in such a manner that they become loose whenever the tension applied to the ribbon tapes on them exceeds a threshold value.

With a method and an apparatus as described above, the ribbon tapes produced by splitting a broad roll of amorphous metal foil are alternately taken up by upper and lower take-up reels to avoid and friction between them. Although the tensions applied to the ribbon tapes may vary from one another, causing differences to take place in the rate of rotation of the take-up reels, those take-up reels carrying ribbon tapes under high tension becomes loosely held by holding means so that all the ribbon tapes show a substantially equal tension as they are taken up by the take-up reels.

Each of the holding means to be used for the purpose of the above method and apparatus may be realized in the form of a layered and ring-shaped sheet made of a were-resistive material having a low coefficient of friction and tightly held either between two adjacent reels or at a lateral side of a reel by a pair of keep plates fitted to the related rotary shaft. Materials that may be used for them include polytetrafluoroethylene (trade name : Teflon) filled with glass fiber, graphite, carbon, bronze, molybdenum disulfide or a compound of any of them and super high molecular weight polyethylene (trade name : Hyzex Million). The layered ring-shaped sheet may be coated with a material selected from those listed above. The layered ring-shaped sheet may be replaced by a sleeve to be fitted between the take-up reel and the rotary shaft, the sleeve having a inner or outer peripheral surface having a large coefficient of friction. Alternatively, the layered ring-shaped sheet may be replaced by a piece made of a material having a large coefficient of friction to be fitted to at least either the take-up reel or the rotary shaft.

When a ring-shaped sheet as described above is arranged between two adjacent reels, they may smoothly slide relative to each other if more than one such sheets are provided. The sheets arranged at a same spot may be those made of either a same material or different materials. A composite sheet prepared by bonding a rubber sheet and a polytetrafluoroethylene sheet containing glass fiber by using a piece of double side adhesive tape is particularly preferable when a pair of such composite sheets are put together with their rubber sheet sides facing outward and disposed between two adjacent reels so that they are in contact with the take-up reels. The effect of the composite sheets will be significantly enhanced when more than one pieces glass cloth impregnated with polytetrafluoroethylene dispersed from the composite sheets are arranged between them.

With a method and an apparatus as described above, any of the take-up reels becomes idle when the tension applied to the ribbon tape on it is too large so that all the ribbon tapes may have an equal level of tension. However, there arises a problem that the rate at which the take-up reels take up ribbon tapes increases and therefore the tension applied to each of the tapes also increases as the reels come to carry a large volume of ribbon tapes, leading to a high frequency of idly running reels. This problem is resolved by providing an arrangement with which the take-up reels is held to the respectiv rotary shafts with an increased power as the volume of ribbon tapes they carry augments. If th means for holding the take-up reels to the rotary shafts consists in ring-shaped sheets arranged between adjacent reels and squeezed by a pair of ke p plates from lateral sides, the problem can be resolved by providing keep plates that hold take-up r els with an increased power as the volume of ribbon tapes the re ls carry augments. Such an arrangement involves sensors for d tecting the volume of ribbon tapes on the take-up reels and controlling the power with which the take-up reels are slidably

held to the respective rotary shafts by keep plates.

The mechanism for pushing a keep plate against a take-up reel may be an air cylinder, a cam device that shifts the position of the keep plate by means of a lift or a device designed to shift the position of the keep plate by pivotal movement of a lever.

The fourth object of the invention can be alternatively achieved by providing a method and an apparatus for separately taking up individual ribbon tapes produced by splitting a broad roll of amorphous metal foil by take-up reels arranged zigzag and driven by respective motors are characterized by that each of the tape take-up reels is arranged on a separate rotary shaft and driven by a separate motor and provided with a tension sensor for detecting the tension applied to the ribbon tape and controlling the rate of rotation of the motor.

With a method and an apparatus as described above, the rate of taking up each of the ribbon tapes is separately controlled as a function of the tension applied to the ribbon tape in order to achieve an equal level of tension for all the ribbon tapes. While the arrangement of providing each of the ribbon tapes produced by splitting a broad roll of amorphous metal foil with a take-up reel, a rotary shaft, a motor for driving the rotary shaft and a tension sensor will not arise any problem so long as the number of the ribbon tapes is small, the overall apparatus will become complex and excessively bulky if the number of ribbon tapes is large.

This problem can be avoided by dividing the take-up reels into two groups arranged on different levels, an upper group of reels and a lower group of reels which are fitted to respective rotary shafts, each of the reels being provided with a holding means that holds the reel to the rotary shaft in such a manner that it becomes idle on the rotary shaft whenever the tension applied to any of the ribbon tapes of the group it belongs exceeds a given threshold value as it is detected by a sensor arranged for that group of reels on a common rotary shaft driven by a rotary motor, the rate of rotation of which is also controlled by the sensor. With such an arrangement, since a plurality of take-up reels are fitted to a common rotary shaft driven by a single drive motor without sacrificing the tension regulating capability of the apparatus, the size of the apparatus can be minimized.

Although the ribbon tapes obtained by splitting a broad roll of amorphous metal foil can be taken up by simply driving the take-up reels to rotate by motors, the tapes are subjected to considerable tension as the original roll is split into ribbon tapes and eventually reaches the take-up reels because of the large torque required for driving the take-up reels in order to offset the resistance the tapes receive as they pass through the cutters and the guide rolls. Therefore, it is recommendable to arrange pinch rolls between the cutters and the take-up reels to preliminarily pull the tapes in order to alleviate the tension applied to the tapes when they are taken up by the take-up reels.

When pinch rolls are arranged between the cutters and the take-up reels, one or more than one tension sensors are preferably arranged between the cutters and the pinch rolls to detect the tension applied to the tapes in that area to control the drive motor for driving the pinch rolls accordingly.

With a method according to any of claims 1 through 3 of the present patent application, any meandering motion of the original roll due to irregular thickness of the amorphous metal foil and uneven lateral margins of the original roll is corrected so that the original roll be placed perpendicular to the cutters at a right position. Moreover, the rate of feeding the original roll is auto-matically adjusted depending on the rate of splitting the original roll so that the tension applied to the original roll is maintained to a right degree even during the rise time required for the foil feeder reel to reach a constant rate of rotation from the start of motion.

With a method according claim 4 of the present patent application, the rate of rotation of the original roll driving motor is modified according to the degree of slackness of the original roll to adjust the feeding of the original roll so that it may be fed to the cutters under appropriate tension.

With a method according to claim 5 of the present patent application, the rate of rotation of the drive motor for feeding the original roll is modified according to the volume of the original roll left on the foil feeder reel so that the original roll is fed at a constant rate regardless of the volume left on the foil feeder reel to avoid any excessive or lack of tension of the original roll.

With a method according to claim 6 of the present patent application, the operation of splitting amorphous metal foil is conducted at a very elevated rate of between 100 and 200 m/min. Moreover, since the trashy ribbon tapes produced from the lateral marginal portions of the original roll are blasted to small pieces having a relatively small volume so that they can be put into a limited number of bags for disposal and consequently the space required for storing the bags as well as the cost of waste disposal can be significantly reduced. Besides, the blasted ribbon tapes may be placed betw en plastic or plywood sheets to form a magnetic shield panel to be used for magnetically shielding magnetic field generating cables, medical instruments or computers or for other recycling applications.

With a method and an apparatus according to claim 7 or 9, the tape blasting capability of the apparatus can be enhanced by mixing trashy tapes with compressed air as more scars are formed on the tapes.

With a method and an apparatus according to claim 8 or 10, th tape blasting capability of the apparatus can be further enhanced ribbon tapes from the two lateral marginal porti ns of an original roll are collected

together to collide against each other and produc more scars, although a single mixer and a singl blasting pipe are commonly used to simplify the configuration of the apparatus.

With a method and an apparatus according to claim 11 or 14, ribbon tapes obtained by splitting an original roll of amorphous metal foil are taken up by respectiv take-up reels with an equal level of tension and without producing any slackened ribbon tapes even the ribbon tapes hav thicknesses which are irregular and different from one another. Such an arrangement can effectively eliminate any unintentionally broken ribbon tapes and raise the speed of splitting operation to reduce the cost of manufacturing ribbon tapes. Moreover, since the ribbon tapes on the take-up reels can be retracted evenly under an equal level of tension, the overall yield of the process is greatly improved.

With a method and an apparatus according to claim 12 or 28, since the pressure applied to the take-up reels is modified according to the volume of ribbon tapes carried by the reels, any of the take-up reels would not become idle even the volume on it reaches an enhanced level.

With a method and an apparatus according to claim 13, 15 or 18, the tension applied to each of the ribbon tapes produced by splitting an original roll of amorphous metal foil can be maintained to an appropriate level. With an apparatus according to claim 16, the tensions applied to the ribbon tapes obtained from an original roll are equalized to an appropriate level, while the apparatus is realized to a simple configuration.

With an apparatus according to claim 17 of the present patent application, the tension applied to each of the ribbon tapes as it is taken up by a take-up reel is alleviated to avoid any unintentional breakage or elongation of the ribbon tape.

Now, the present invention will be described in greater detail by referring to the accompanying drawings that illustrate a preferred embodiment of the invention.

Fig. 1 is a schematic illustration of an amorphous metal foil ribbon tape manufacturing apparatus according to the invention.

Fig. 2 is a schematic illustration of a trash ribbon tape blasting apparatus.

Fig. 3 is a sectional view of a principal part of a ribbon tape take-up apparatus.

An original roll reel 11 carries a roll of amorphous metal foil 12 having a width of between 1.00 and 213 mm and a thickness of between 24 and 26 μm at the center and between 21 and 23 μm at the lateral edges, which is gradually unwound from the original roll reel 11 and fed by way of a dancer roll 13, pinch rolls 14, anti-meander device 15 and a tension sensor to rotary cutters 17 having upper and lower edges, by which the amorphous metal foil 12 is split into a number of ribbon tapes 18, which are separated into an upper group and a lower groups and fed further by way of respective tension sensors 20, pinch rolls 21 and tension sensors 22 to take-up reels 23 that take up the respective ribbon tapes 18. The original roll reel 11 is driven clockwise in Fig. 1 by a DC motor 24 by way of a reduction gear 25 and the upper and lower edges of the rotary cutters 17 are also rotated clockwise by a DC motor 26 by way of a reduction gear 27. The output voltage of the DC motor 26 is detected to control the voltage of the DC motor 24 by means of a controller 28 as a function of the output voltage of the DC motor 26 so that the ratio of the rate of rotation of the DC motor 24 and that of the DC motor 26 always agrees with a given value.

The dancer roll 13 moves upward or downward depending on the degree of slackness of the amorphous metal foil 12 and its displacement from a reference level is converted into a voltage signal. When the dancer roll 13 is located above the reference level, the voltage signal has a positive value, whereas it shows a negative value if the dancer roll 13 is found below the reference level. A positive voltage signal causes the DC motor 24 to increase its rate of rotation, whereas a negative voltage signal gives rise to an decrease in the rate of rotation of the DC motor 24. As the rate of rotation of the DC motor 24 is increased by a positive voltage signal, the rate of feeding the amorphous metal foil 12 augments, whereas it goes down as the rate of rotation of th DC motor 24 is decreased by a negative voltage signal.

The up and down movement of the pinch rolls 14 is harnessed by a powder brake 29 that operates in accordance with the tension of the amorphous metal foil 12 detected by the tension sensor 16 so that the tension is always kept constant.

The anti-meander device 15 consists of a light emitting unit and a light receiving unit which are juxtaposed at the lateral sides of the roll of amorphous metal foil 12 and comprises an optical sensor 31 for detecting an edge of the amorphous metal foil 12, a pair of horizontally rotatable rolls 32 and a servo-motor 33 which is actuated to horizontally rotate the rolls 32 to alter the angle between them by an output signal generated by and transmitted from the light receiving unit when the beam of light from the light emitting unit to the light receiving unit is interrupted. Two anti-meander devices are provided to form a front device and a rear device.

Two guide pipes are arrang d downstream to th cutters 17, each of the guide pipes b ing provided with a sensor 35 for detecting an edge of a trashy ribbon tape 18 produced from a lateral marginal portion of the amorphous metal foil 12 and a tape inlet port arranged near the cutt r for the trashy ribbon tape 18 for receiving it. Each of the two guide pipes 36 is connected to an ejector 37 as shown in Fig. 2.

As seen from Fig. 2, the ejectors 37 are connected to a mixer 38 having a large diameter in the form of letter Y. They operate to transfer trashy ribbon tapes into the mixer 38 by compressed air blown in from an air compressor (not shown) through the respective neck portions so that the trashy ribbon tapes collide against and damage one another.

The compressed air supplied to the ejectors 37 may be blocked by change-over valves (not shown) according to output signals transmitted from the sensors 35. Whenever either of the sensors 35 detects the front edge of a ribbon tape 18, the change-over valves are opened to allow compressed air to flow into the ejectors from the air compressor. Likewise, the change-over valves are closed to block the compressed air from flowing into the ejectors whenever the rear edge of a ribbon ink is detected by either of the sensors 35.

The mixer 38 is also connected to an iron pipe 39 having a diameter smaller than its own so that entangled trashy ribbons coming out from the mixer 38 with compressed air collide against the inner wall of the iron pipe 39 and are blasted to pieces before they are received by a metal mesh dust collector 40.

Each of the tension sensors 20 and 22 is so designed that it vertically shifts its position depending on the degree of tension of the ribbon tape for which it is responsible and generates a voltage signal that corresponds to its positional displacement, which is then transmitted to the controller 28. The controller 28, upon receiving a voltage signal either from the tension sensor 20 or 22 so controls the torque motor 42 for driving the pinch rolls or the torque motor 43 for driving the rotary shaft that the ribbon tapes restore the specified level of tension.

The take-up reels 23 are divided into four groups and rotatably disposed on the respective rotary shafts 44 arranged at four vertically and horizontally different positions. Take-up reels 23 on a common rotary shaft are arranged at a constant pitch. As shown in Fig. 3, a pair of ring-shaped composite sheets 47, each prepared by bonding a rubber sheet 45 and a sheet of glass fiber reinforced polytetrafluoroethylene 46 by means of a double side adhesive tape, are disposed between two adjacent take-up reels 23 with the rubber sheets 45 placed in contact with the reels. A ring-shaped sheet 48 made of glass cloth impregnated with dispersed polytetrafluoroethylene is placed between each pair of composite sheets. Each of the take-up reels 23 accompanied by two pairs of composite sheets 47 and a pair of glass cloth sheets 48 are pinched from the lateral sides by a pair of keep plates 49a and 49b, of which the keep plate 49a is rigidly fitted to the rotary shaft 44 while the keep plate 49b is slidably fitted to the rotary shaft by means of a key 50. The keep plate 49b is connected to an air cylinder 51 in such a manner that it can slide to the left on the rotary shaft as seen in Fig. 3 under the influence of the air cylinder 51 to further squeeze the take-up reel 23. The rate of sliding motion of the keep plate 49b is controlled by a flow rate regulator valve 52 of the air cylinder 51.

Each of the rotary shafts 44 is also provided with a sensor 54 for detecting the volume of the ribbon tape 18 taken up by one of the take-up reels 23 it carries. (Fig. 1 shows only one of the sensors arranged on the rotary shafts.) Each of the sensors is provided with a spindle (indicated by an arrow pointing the lowest take-up reel 23 in Fig. 1) which is radially movable depending on the volume of the ribbon tape 18 carried on the take-up reel 18. The displacement of the spindle is converted to a voltage signal and transmitted to the controller 28, which determines the side pressure required to be applied to the take-up reels 18 on the rotary shaft 44 as a function of the detected volume of ribbon tape by calculation using a set of empirical formulas, controls the flow rate regulator valve 52 to actuate the air cylinder 51 and move the keep plate 49b so that the side pressure being applied to the reels agrees with the calculated value. In short, as the volume of taken up ribbon tapes increases, so is increased the side pressure applied to the take-up reels 23 correspondingly in order to avoid any idle motion of any of the take-up reels 23 due to the increased volume of taken up ribbon tapes.

In a series of experiments conducted by the inventor of the present invention by using the embodiment, the rate of splitting amorphous metal foil (the rate at which the roll of amorphous metal foil is fed to the rotary cutters) was normally between 80 and 250 m/min and advantageously between 100 and 200 m/min, which is considerably greater than the rate available with any existing apparatus.

[Example 1]

Using an apparatus as shown in Figs. 1 and 2, a roll of amorphous metal foil was split at a rate of 200 m/min. Air was blown into the ejectors 37 under a pressure of 5 kg/cm^3 and trashy ribbon tapes produced from the lateral marginal portions of the roll were taken into the guide pipes 36, mixed in the mixer 38 and then passed through the iron pipe 39 to be blasted to small pieces having a length b tween 1 and 50 mm. The volume of the blasted ribbon tapes was less than 1/100 of their volume before the blasting. The iron pipe had an inner diameter of 28 mm and a length of 130 cm.

[Example 2]

A 101.6 mm wide roll of amorphous metal foil was split by cutters to produce nine 10 mm wide ribbon tapes,

which were taken up by take-up reels arrang alternately high and low, five high-positi ned reels and four low-positioned reels, at a rate of 100 m/min. All the nine ribbon tapes were taken up under appropriate t nsion without showing any slack. No broken tapes were bserved during the operation. The tak n up ribbon tapes w re squarely and neatly carried by the reels without showing any looseness.

The take-up r els were made of hard vinylchloride and had an inner width f 12 mm, an outer width of 16 mm, an core diameter of 160 and an outer diameter of 380 mm.

A pair of composite sheets, each prepared by bonding a 0.5 mm thick rubber sheet and a 1.0 mm thick polytetrafluoroethylene sheet containing glass fiber with a double adhesive tape, and a sheet, prepared by impregnating and dispersing polytetrafluoroethylene in a 100 µm thick glass cloth and arranged between the composite sheets, were placed between two adjacent reels. Each of the sheets has a form of a ring having an inner diameter of 71 mm and an outer diameter of 107 mm.

[Example 3]

An experiment same as that of Example 2 above except that the polytetrafluoroethylene sheets containing glass fiber were replaced by so many high molecular weight polyethylene sheets was conducted to produce nine ribbon tapes which were taken up by take-up reels under appropriate tension without showing any slack. No ribbon tapes were broken during the experiment. The taken up ribbon tapes were squarely and neatly carried by the reels without showing any looseness.

[Example 4]

A 170.18 mm wide roll of amorphous metal foil was split by cutters at a rate of 200 m/min to produce sixteen 10 mm wide ribbon tapes, which were taken up by take-up reels arranged alternately at a high position and a low position and pivotally supported by two shafts located at the respective positions, each carrying eight reels.

All the sixteen ribbon tapes were taken up under appropriate tension without showing any slack. No ribbon tapes were broken during the experiment. The taken up ribbon tapes were squarely and neatly carried by the reels without showing any looseness.

The take-up reels were made of hard vinylchloride and had an inner width of 12 mm, an outer width of 16 mm, an core diameter of 160 and an outer diameter of 380 mm.

A pair of composite sheets, each prepared by bonding a 0.5 mm thick rubber sheet and a 0.3 mm thick polytetrafluoroethylene sheet containing glass fiber with a double adhesive tape, and a sheet, prepared by impregnating and dispersing polytetrafluoroethylene in a 100 µm thick glass cloth and arranged between the composite sheets, were placed between two adjacent reels. Each of the sheets has a form of a ring having an inner diameter of 71 mm and an outer diameter of 107 mm.

[Example 5]

A 170.18 mm wide roll of amorphous metal foil was split by cutters at a rate of 200 m/min to produce thirty three 5 mm wide ribbon tapes, which were taken up by take-up reels arranged alternately at a high position and a low position and pivotally supported by four shafts located at the respective positions, carrying respectively eight, eight, eight and nine reels.

All the thirty three ribbon tapes were taken up under appropriate tension without showing any slack. No ribbon tapes were broken during the experiment. The taken up ribbon tapes were squarely and neatly carried by the reels without showing any looseness.

The take-up reels were made of hard vinylchloride and had an inner width of 7 mm, an outer width of 13 mm, an core diameter of 160 and an outer diameter of 380 mm.

A pair of composite sheets, each prepared by bonding a 0.5 mm thick rubber sheet and a 0.3 mm thick polytetrafluoroethylene sheet containing glass fiber with a double adhesive tape, and a sheet, prepared by impregnating and dispersing polytetrafluoroethylene in a 100 µm thick glass cloth and arranged between the composite sheets, were placed between two adjacent reels. Each of the sheets has a form of a ring having an inner diameter of 71 mm and an outer diameter of 107 mm.

Claims

1. A method of splitting a broad roll of amorphous metal foil fed from a foil fe der reel into a plurality of ribbon tapes by rotary cutters and taking them up on take-up reels, said method comprising eliminating any mean-

dering motion of the roll of amorphous metal foil by using a sensor for detecting the lateral edges of the roll and a pair of rollers the angle between which is controlled according to the output signal from the sensor and operating a drive motor for driving the rotary cutters and a drive motor for feeding amorphous metal foil with a constant ratio of rotation.

2. A method according to claim 1, further comprising controlling the drive motor for feeding amorphous metal foil by detecting the displacement of a dancer roll arranged between the foil feeder reel and the rotary cutters in such a manner that it is firmly kept in contact with the amorphous metal foil and moves back and forth as a function of the tension of the amorphous metal foil.

3. A method according to claim 1 or 2, wherein the volume of amorphous metal foil remaining on the foil feeder reel is detected by a sensing means and the drive motor for feeding amorphous metal foil is controlled as a function of the detected volume.

4. A method of splitting a broad roll of amorphous metal foil fed from a foil feeder reel into a plurality of ribbon tapes by rotary cutters and taking them up on take-up reels, comprising controlling a drive motor for feeding amorphous metal foil by detecting the displacement of a dancer roll arranged between foil feeder reel and the rotary cutters in such a manner that it is firmly kept in contact with the amorphous metal foil and moves back and forth as a function of the tension of the amorphous metal foil.

5. A method of splitting a broad roll of amorphous metal foil fed from a foil feeder reel into a plurality of ribbon tapes by rotary cutters and taking them up on take-up reels, wherein the volume of amorphous metal foil remaining on the foil feeder reel is detected by a sensing means and the drive motor for feeding amorphous metal foil is controlled as a function of the detected volume.

6. A method of splitting a broad roll of amorphous metal foil fed from a foil feeder reel into a plurality of ribbon tapes by rotary cutters and taking them up on take-up reels, comprising introducing trash ribbon tapes produced by marginal portions of a roll of amorphous metal foil into a hard blasting pipe and transferring them by compressed air.

7. A method according to claim 6, wherein the trash ribbons tapes of amorphous metal foil are mixed with compressed air in a mixer and thereafter introduced into a hard blasting pipe.

8. A method according to claim 7, wherein the trash ribbons produced by two lateral marginal portions of a roll of amorphous metal foil are collected and mixed in said mixer.

9. An apparatus for carrying out the method according to claim 8, comprising an ejector for collecting trash ribbon tapes produced during the operation of splitting a roll of amorphous metal foil by way of a collector pipe, a mixer for mixing the trash ribbon tapes collected by the ejector with compressed air and a hard blasting pipe connected to the mixer.

10. An apparatus according to claim 9, wherein a pair of guide pipes are provided for guiding trash ribbon tapes produced from respective lateral marginal portions of a roll of amorphous metal foil into the mixer.

11. A method of separately taking up individual ribbon tapes produced by splitting a broad roll of amorphous metal foil by take-up reels arranged in relatively offset groups on rotary shafts and driven by respective motors, wherein the groups of take-up reels are rotatably arranged on common shafts and held by holding means in such a manner that they become loose whenever the tension applied to the ribbon tapes on them exceeds a threshold value.

12. A method according to claim 11, wherein the v lume of ribbon tape on each take-up reel is detected by a sensor and the force with which the take-up reel holds its rotary shaft is modified as a function of the detected volume of ribbon tape.

13. A method of separately taking up individual ribbon tapes produced by splitting a broad roll of amorphous metal f il by take-up reels arranged in relatively offset groups n rotary shaft and driven by respective motors, wherein the groups of tape take-up reels are arranged on respective common rotary shafts and driven by respective motors, each group of take-up reels being provided with a tension sensor for detecting

the tension applied to the ribbon tape and controlling the rate of rotation of the motor.

14. An apparatus for separately taking up individual ribbon tapes produced by splitting a broad roll of amorphous metal foil by take-up reels arranged in relatively offset groups on rotary shafts and driven by respective motors, wherein said apparatus comprises ribbon tape take-up apparatuses, each of which carries a rotary shaft and provided with a holding means for rotatably supporting the take-up reels arranged on it in such a manner that the take-up reels become loose on the rotary shaft whenever the tension applied to any of the ribbon tapes on it exceeds a given threshold value.

15. A ribbon tape take-up apparatus according to claim 14, wherein said holding means is arranged at least a lateral side of the take-up reels.

16. A ribbon tape take-up apparatus according to claim 14, or 15 wherein said holding means comprises a sleeve arranged between the rotary shaft and each of the take-up reels carried on it.

17. A ribbon tape take-up apparatus according to claim 14 or 15 wherein said holding means comprises a piece of abrasion-resistive material having a low coefficient of friction as coating which is held against a lateral side of each reel by a keep plate.

18. A ribbon tape take-up apparatus according to claim 14, wherein said holding means is a ring-shaped sheet made of an abrasion-resistive material having a low coefficient of friction as coating which is squeezed by a pair of keep plates between two adjacent reels.

19. A ribbon tape take-up apparatus according to claim 18, wherein said ring-shaped sheet is applied to a lateral side of a reel in place of holding it between two adjacent reels.

20. A ribbon tape take-up apparatus according to claim 18. wherein at least one of the keep plates is slidable on the rotary shaft and moved by a moving means controlled by a controller according to an output signal transmitted from a sensor that detects the volume of ribbon tape carried by a take-up reel for which it is responsible.

21. A ribbon tape take-up apparatus according to any one of claims 14 to 20, wherein said sheet comprises a plurality of layers.

22. A ribbon tape take-up apparatus according to claim 21, wherein a part of or whole the sheet comprises a plurality of layers which prepared by impregnating and dispersing polytetrafluoroethylene in glass cloth.

23. A ribbon tape take-up apparatus according to claim 22, wherein said sheet comprise a pair of composite sheets, each prepared by bonding a rubber sheet and a polytetrafluoroethylene sheet containing glass fiber by a double adhesive tape and placed between two adjacent take-up reels with the rubber sheets facing the lateral sides of the reels.

24. A ribbon tape take-up apparatus according to claim 22 or 23, wherein said sheet comprises a pair of composite sheets, each prepared by bonding a rubber sheet and a high molecular weight polyethylene sheet by a double adhesive tape, and placed between two adjacent take-up reels with the rubber sheets facing the lateral sides of the reels.

25. An apparatus for separately taking up individual ribbon tapes produced by splitting a broad roll of amorphous metal foil by take-up reels arranged in relatively offset groups on rotary shafts and driven by respective motors, wherein said apparatus comprises ribbon tape take-up apparatuses, each being responsible for a rotary shaft driven by a motor and carrying a ribbon take-up reel, each of the take-up reels being provided with a tension sensor for detecting the tension applied to the ribbon tape and a controller for controlling the rate of rotation of the motor.

26. An apparatus for separately taking up individual ribbon tapes produced by splitting a broad roll of amorphous metal foil by take-up reels arranged on a plurality of rotary shafts driven by respective motors, wherein said apparatus comprises a ribbon tape take-up apparatus comprising :

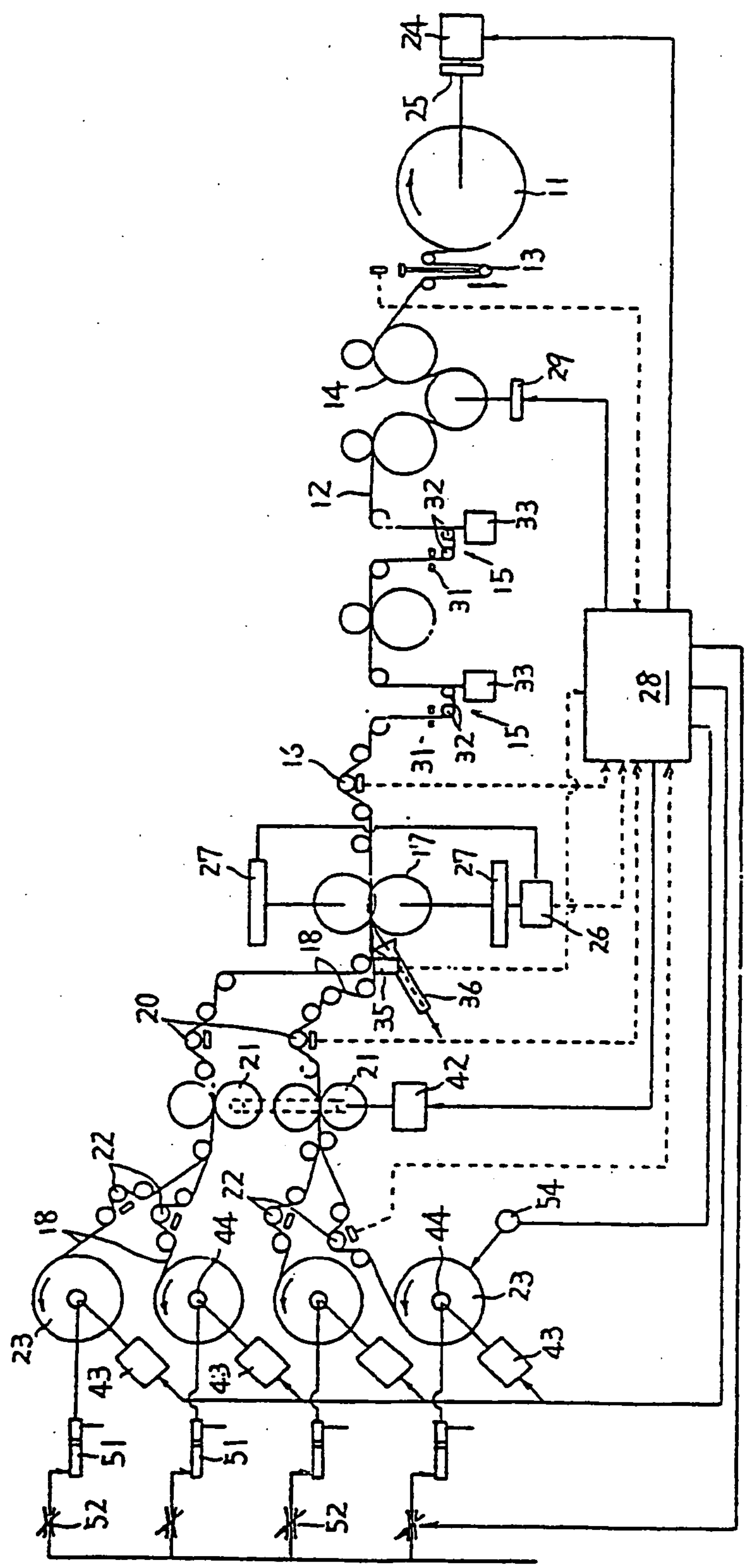
a plurality of take-up reels rotatably arranged on each of the rotary shafts,

a holding means for rotatably supporting the take-up reels in such a manner that the take-up reels on a rotary shaft become loose on it whenever the tension applied to any of the ribbon tapes on it exceeds a given threshold value,
a tension sensor for detecting the tension of tape ribbons for each of the rotary shafts and
a controller for controlling the rate of rotation of the motor as a function of the tension of tape ribbons detected by said sensor.

27. A ribbon tape take-up apparatus according to any one of claims 14 to 26,wherein a pair of pinch rollers are arranged between the cutters and the take-up reels for pulling ribbon tapes from the cutters.

28. A ribbon tape take-up apparatus according to claim 27, wherein the controller controls the rate of rotation of the pinch rollers as a function of the tension of tape ribbons detected by the tension sensor.

FIG.1



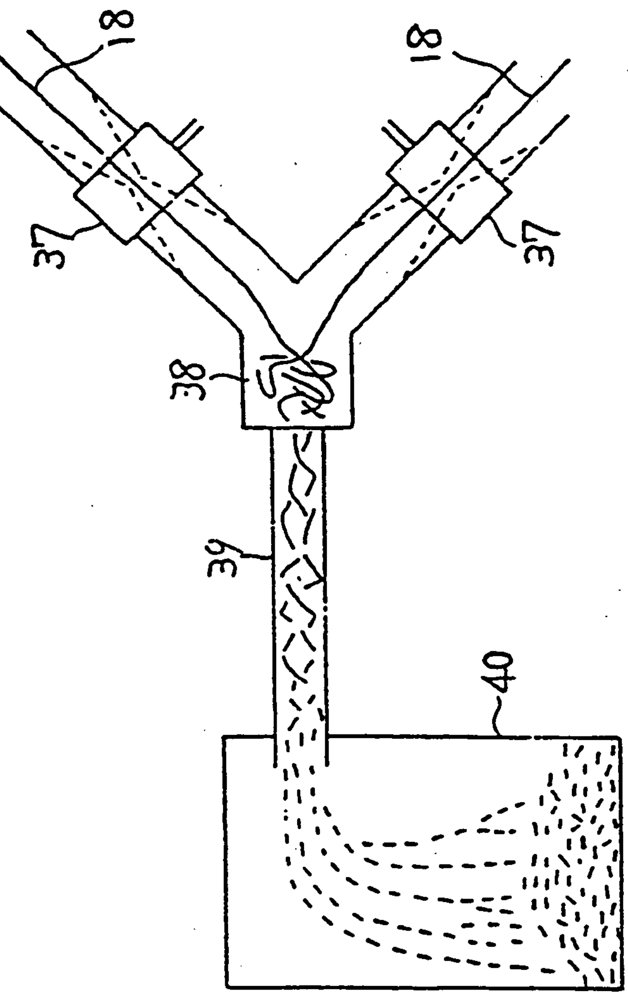


FIG. 2

FIG.3